

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
7 June 2001 (07.06.2001)

PCT

(10) International Publication Number
WO 01/41225 A3

(51) International Patent Classification⁷: **H01L 33/00**

(21) International Application Number: **PCT/US00/42525**

(22) International Filing Date:
28 November 2000 (28.11.2000)

(25) Filing Language: **English**

(26) Publication Language: **English**

(30) Priority Data:
60/168,817 3 December 1999 (03.12.1999) **US**

(71) Applicant: **CREE LIGHTING COMPANY [US/US];**
340 Storke Road, Goleta, CA 93117 (US).

(72) Inventors: **THIBEAULT, Brian;** 1914 Cleveland Avenue, Santa Barbara, CA 93101 (US). **MACK, Michael;** 6864 Bottom Wood Lane, Goleta, CA 93117 (US). **DENBAARS, Steven, P.;** 6266 Marlborough Drive, Goleta, CA 93101 (US).

(74) Agents: **HEYBL, Jaye, G. et al.;** Koppel & Jacobs, Suite 107, 555 St. Charles Drive, Thousand Oaks, CA 91360 (US).

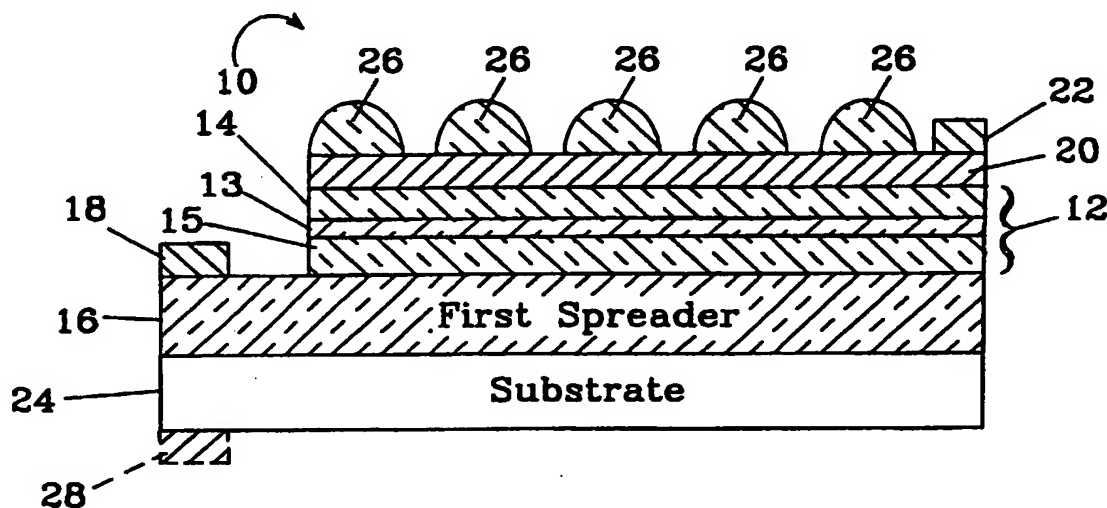
(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— with international search report

[Continued on next page]

(54) Title: **ENHANCED LIGHT EXTRACTION IN LEDS THROUGH THE USE OF INTERNAL AND EXTERNAL OPTICAL ELEMENTS**



(57) Abstract: This invention describes new LEDs having light extraction structures (26) on or within the LED to increase its efficiency. The new light extraction structures (26) provide surfaces for reflecting, refracting or scattering light into directions that are more favorable for the light to escape into the package. The structures can be arrays of light extraction elements (42, 44, 46, 48, 50, 52) or disperser layers (112, 122, 134, 144, 152, 162). The light extraction elements can have many different shapes and are placed in many locations to increase the efficiency of the LED over conventional LEDs. The disperser layers provide scattering centers for light and can be placed in many locations as well. The new LEDs with arrays of light extraction elements are fabricated with standard processing techniques making them highly manufacturable at costs similar to standard LEDs. The new LEDs with disperser layers are manufactured using new methods and are also highly manufacturable.

WO 01/41225 A3



(88) Date of publication of the international search report:
3 January 2002

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

I. International Application No
PCT/US 00/42525

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01L33/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 528 057 A (YANAGASE M ET AL) 18 June 1996 (1996-06-18)	1-7, 13, 20-24, 27, 33, 34, 36
Y	the whole document	15-19, 29-32
Y	US 5 491 350 A (UNNO T ET AL) 13 February 1996 (1996-02-13)	15-19, 29-32
A	the whole document	37
X	WO 99 53578 A (UNIV STRATHCLYDE) 21 October 1999 (1999-10-21)	1, 2, 4, 5, 15-18, 20-23, 29-31, 33, 34, 36, 37, 39
A	the whole document	40

-/--

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *A* document member of the same patent family

Date of the actual completion of the international search

5 July 2001

Date of mailing of the international search report

12/07/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax (+31-70) 340-3016

Authorized officer

van der Linden, J.E.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/42525

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 11 274568 A (HEWLETT PACKARD CO) 8 October 1999 (1999-10-08)	1,2,4,5, 8,11-13, 15,16, 19-27, 29,32-36 37,40
A P,X	-& US 6 091 085 A (AGILENT TECHNOLOGIES) 18 July 2000 (2000-07-18)	1,2,4,5, 8,11-13, 15,16, 19-27, 29,32-36 37,40
P,A	the whole document	
X	EGAWA T ET AL: "Stimulated emission from current injected InGaN/AlGaIn surface emitting diode with Al reflector" ELECTRONICS LETTERS, 1996, vol. 32, pages 486-488, XP006004802 ISSN: 0013-5194 the whole document	1,2,4, 13,14, 20-23, 27,28, 33,36
X	US 5 414 281 A (WATABE S ET AL) 9 May 1995 (1995-05-09)	1-4,13, 15-18, 20-23, 27, 29-33,36 37
A	column 2, line 44 -column 5, line 47	
X	US 5 793 062 A (KISH F ET AL) 11 August 1998 (1998-08-11) cited in the application the whole document	1-5,7,8, 11, 13-15, 19-29, 32-36
X	SCHNITZER I ET AL: "30% External quantum efficiency from surface textured LEDs" APPLIED PHYSICS LETTERS, 1993, vol. 63, pages 2174-2176, XP000404433 ISSN: 0003-6951 cited in the application the whole document	1,4,5,8, 11,13,20
A	DE 26 33 191 A (SIEMENS AG) 26 January 1978 (1978-01-26) the whole document	9,10
A	US 5 557 115 A (SHAKUDA Y) 17 September 1996 (1996-09-17) the whole document	22,33-36
	-/-	

International Application No
PCT/US 00/42525

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	EP 0 977 277 A (IMEC; UNIV BRUXELLES) 2 February 2000 (2000-02-02)	1-4, 8, 11, 13, 14, 20-23, 25-28, 33, 35, 36
P,A	the whole document _____	8, 9

INTERNATIONAL SEARCH REPORT

Information on patent family members

I. International Application No

PCT/US 00/42525

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5528057 A	18-06-1996	JP 6338630 A	06-12-1994
US 5491350 A	13-02-1996	CN 1103512 A,B JP 7193275 A	07-06-1995 28-07-1995
WO 9953578 A	21-10-1999	EP 1072072 A	31-01-2001
JP 11274568 A	08-10-1999	US 6091085 A	18-07-2000
US 5414281 A	09-05-1995	GB 2270199 A,B JP 3139890 B JP 6125111 A	02-03-1994 05-03-2001 06-05-1994
US 5793062 A	11-08-1998	US 6015719 A DE 19629920 A GB 2304230 A,B JP 9107123 A	18-01-2000 13-02-1997 12-03-1997 22-04-1997
DE 2633191 A	26-01-1978	NONE	
US 5557115 A	17-09-1996	JP 8056014 A JP 8064872 A	27-02-1996 08-03-1996
EP 0977277 A	02-02-2000	EP 0977063 A EP 0977064 A EP 0977280 A JP 2000098180 A JP 2000106454 A	02-02-2000 02-02-2000 02-02-2000 07-04-2000 11-04-2000

RECEIVED

JAN 21 2001

KOPPEL, JACOBS, PATRICK & HEYBL